Senate Bill 3 Environmental Flows Science Advisory Committee (SAC)

February 4, 2009

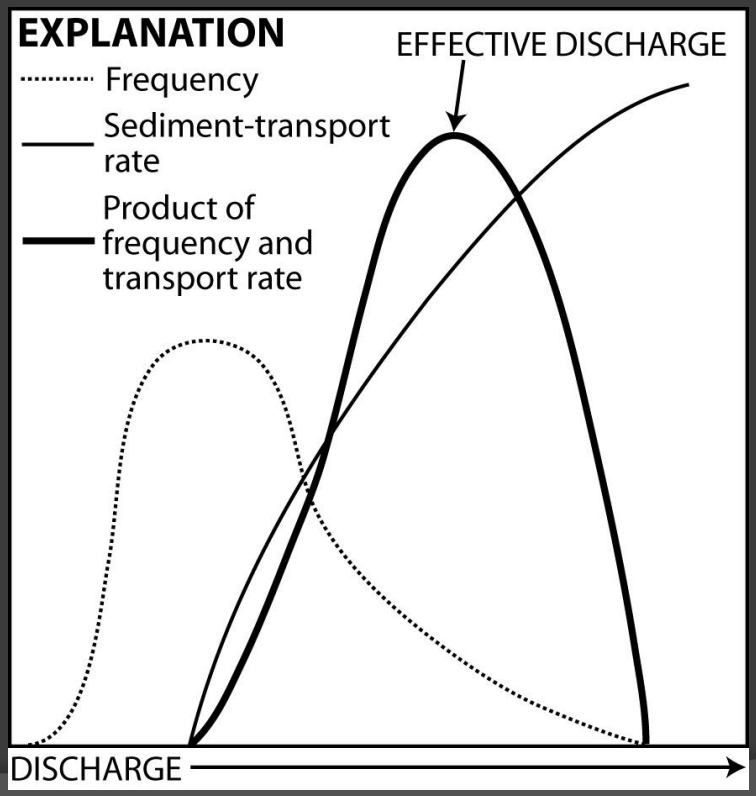
MORE ON SEDIMENT TRANSPORT

Effective discharge

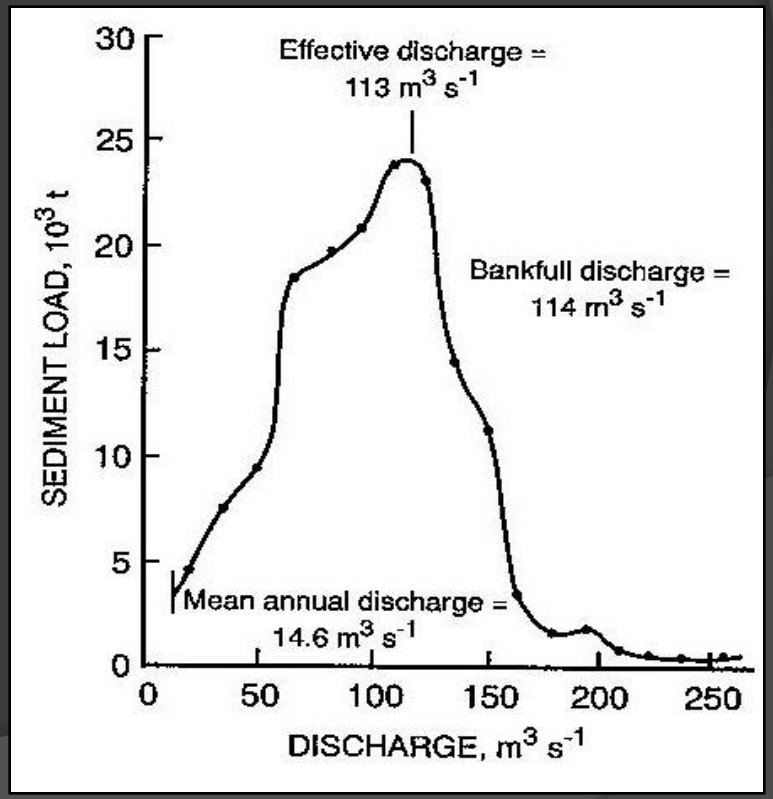
•The flow responsible for the cumulative majority of sediment transport over time

• Maximum of the product of flow frequency and the sediment-transport rate

• Commonly assumed to have a recurrence interval of 1 to 2 years (Wolman and Miller, 1960); further assumption of bankfull

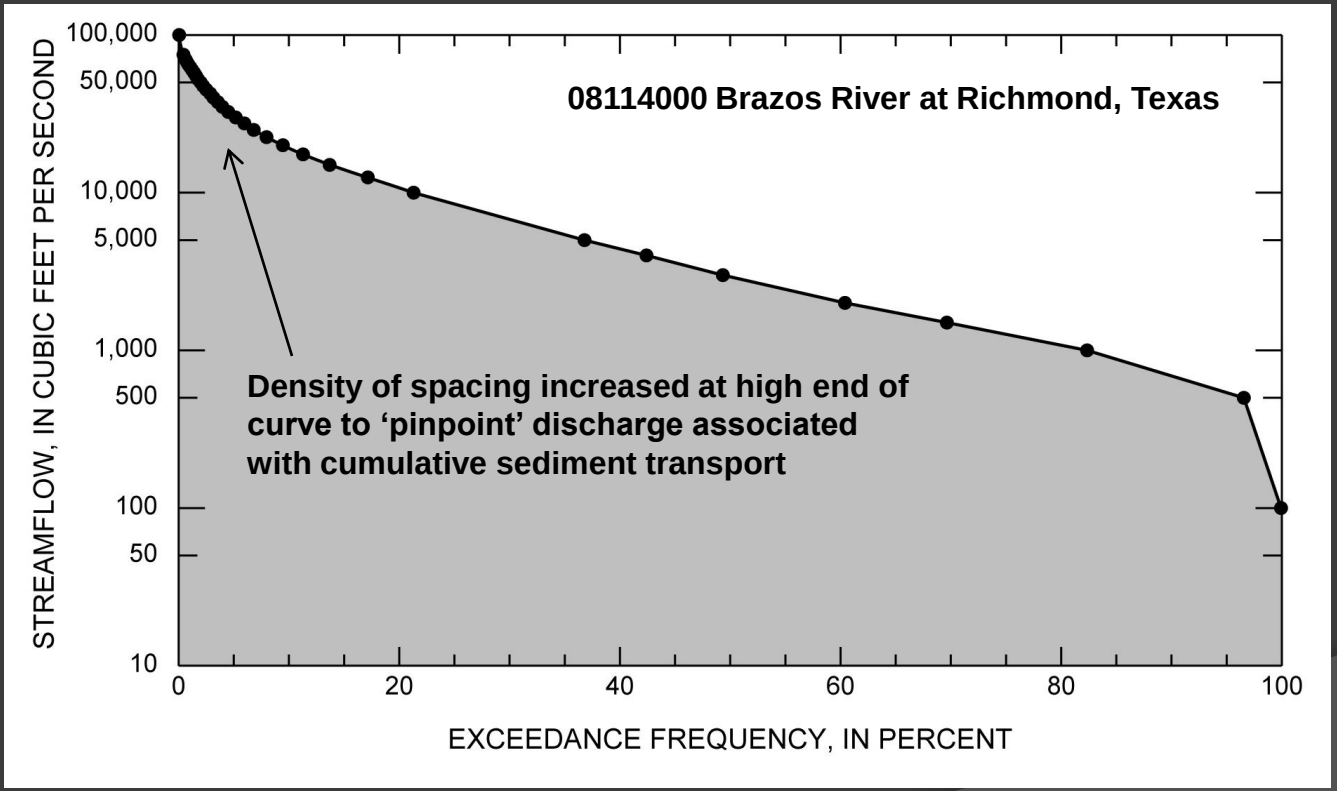


From Wolman and Miller (1960)

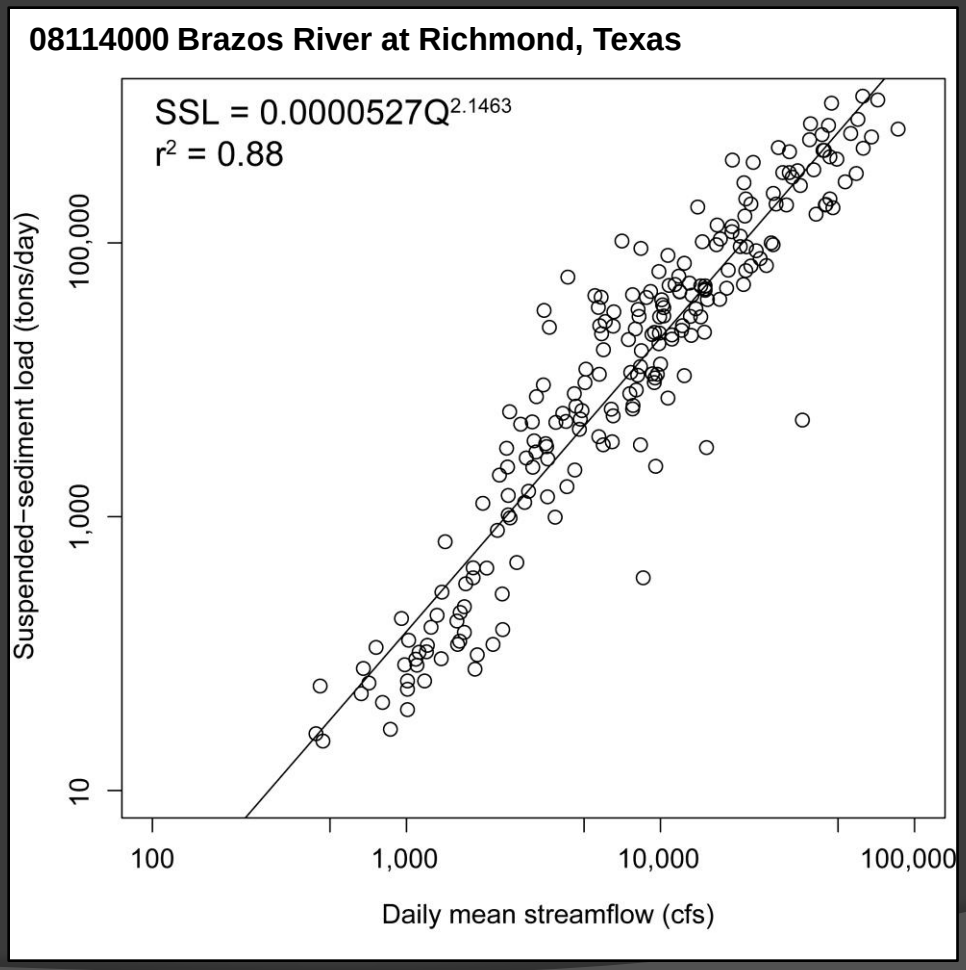


From Andrews (1980); scanned from Knighton (1998)

Flow-duration curve



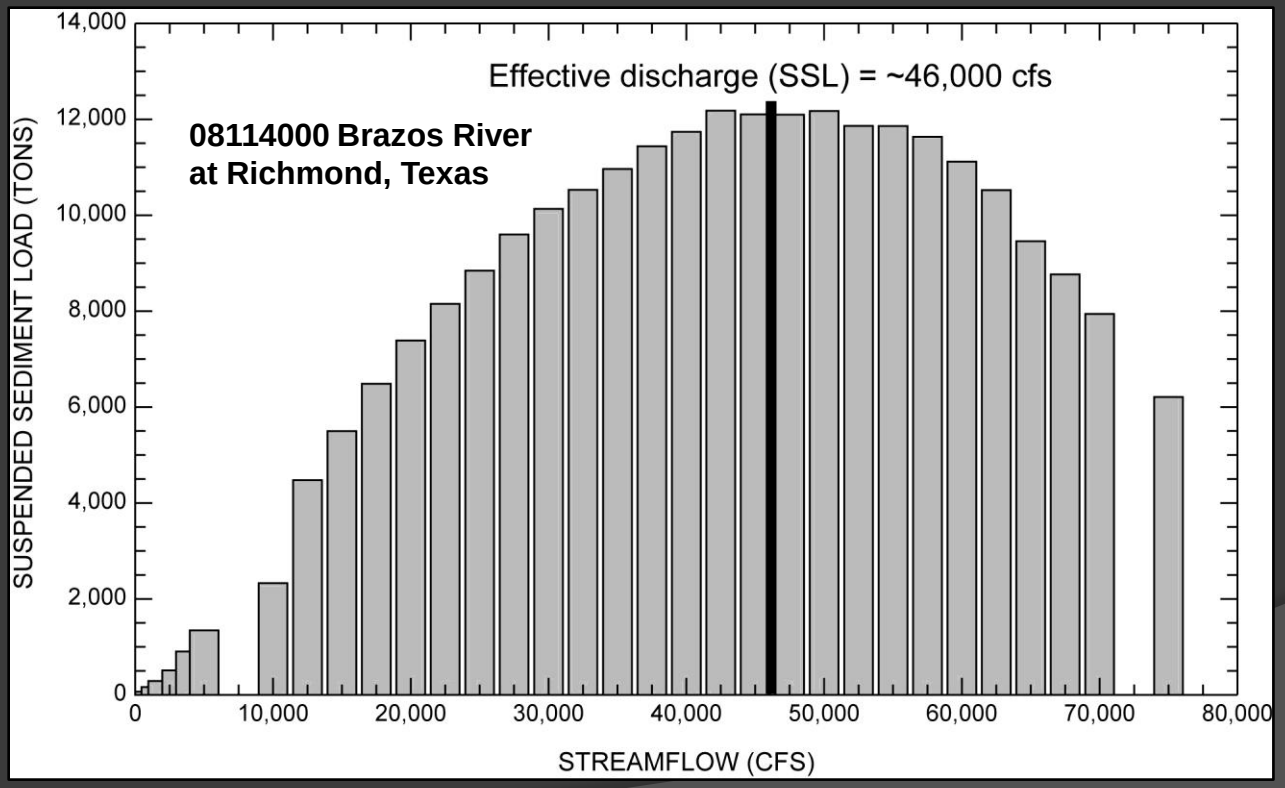
Suspended-sediment load / discharge rating curve



- Plug in 'representative discharge' for each point on the flow-duration curve into the power relation of the sediment-Q rating curve

Suspended-sediment histogram

- Put it in the histogram and determine effective discharge
- All of this is adequately explained in Biedenharn and others (2000)



Decision points

- Period-of-record
- Sediment data
- Discharge class intervals (more at the high end increases accuracy)
- Other decisions regarding implementation

Bedload effective discharge

- Requires application of a bedload model
  - Bagnold (1977) excess stream power for sand bed
    $I_b = (\omega - \omega_c)^{3/2}(d/D_{50})^{-2/3}$

  - Gomez (2006) for gravel bed

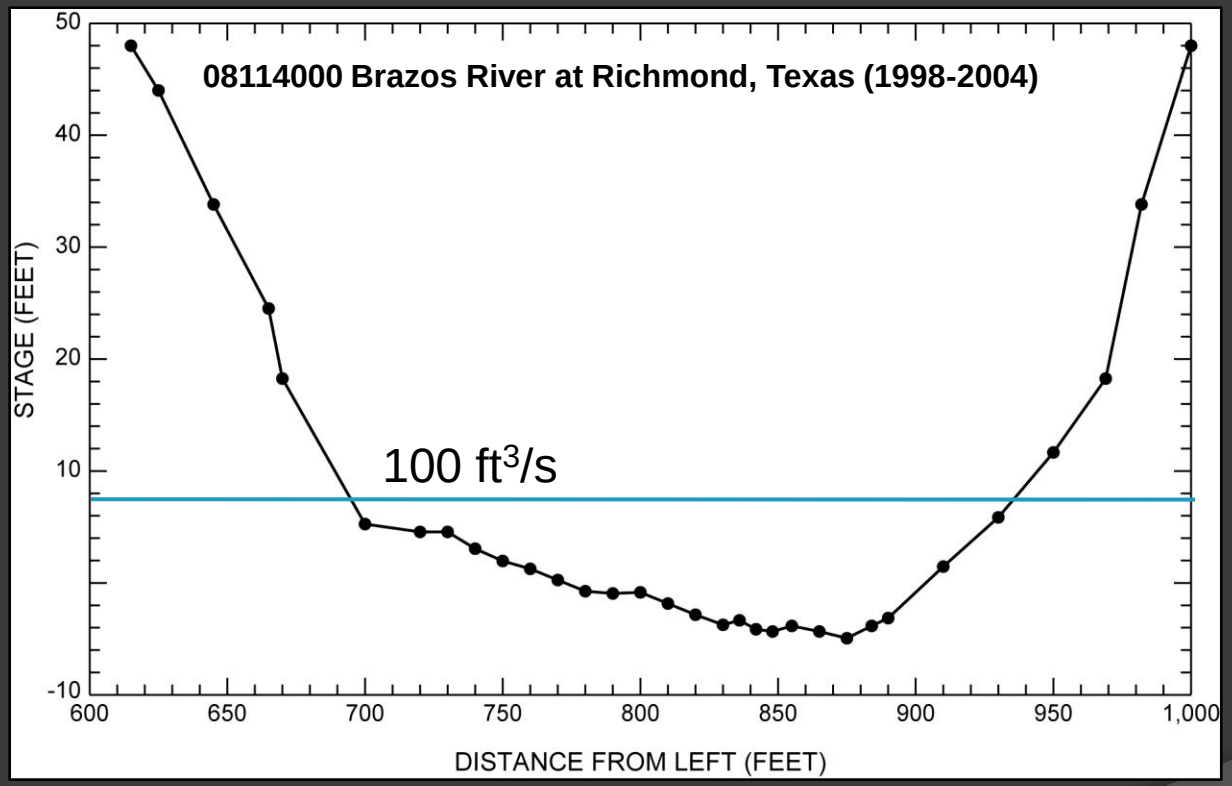
    $I_b = [\omega(0.0115 D_{50}^{-0.51})]/0.63$

    ω is stream power per unit area (W/m^2)
    ω_c is critical stream power (W/m^2)
    D_{50} is median bed-material size (mm)
    d is flow depth (m)

- Requires additional data
  - Representative channel cross section
  - Bed-material particle size
  - Channel slope

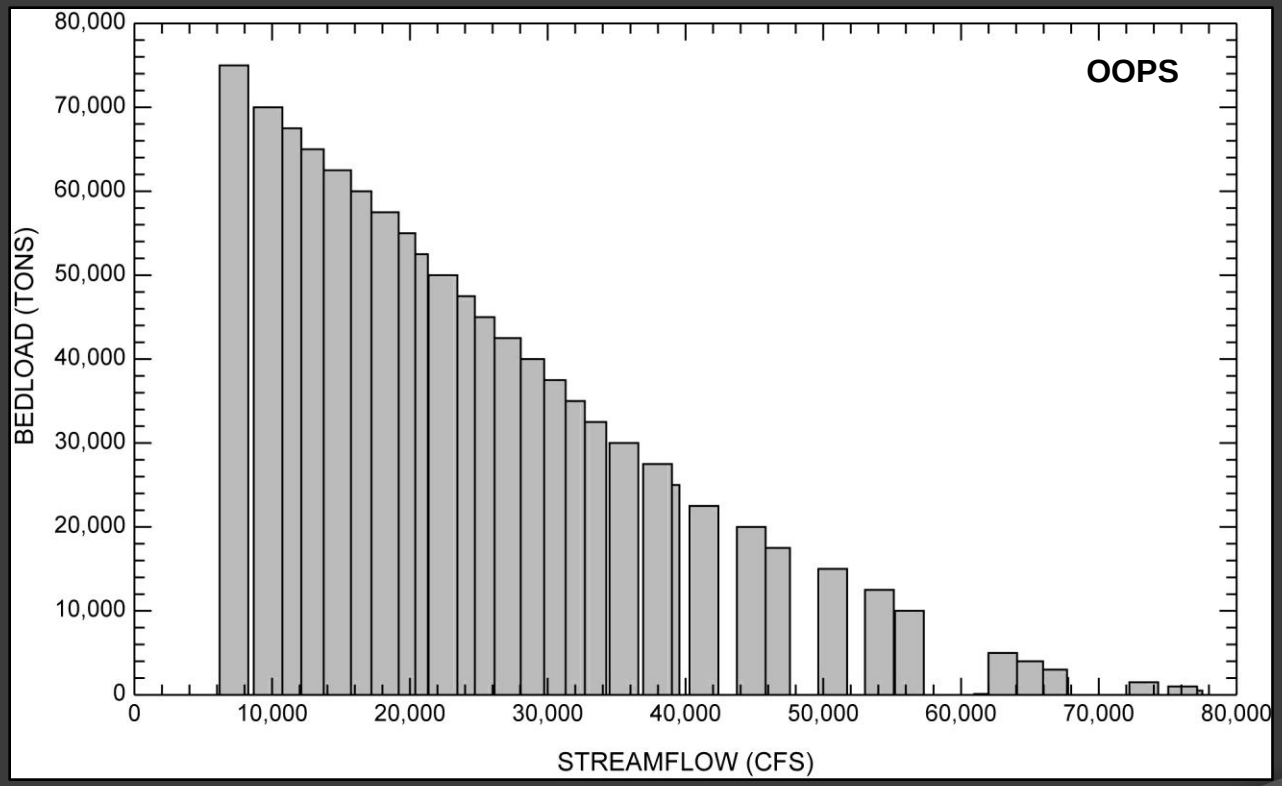
Additional data

- We dangerously assume steady-state equilibrium



- Channel slope: 0.00012
- Median bed-material size: 0.009in
- From National Cooperative Highway Research Program (2004)

Bedload histogram



- Problem occurred because of original cross-section data; USGS stage-Q relations here showed a large cross-sectional area for very low flows (pond-like conditions)
- Hydraulic models, however, used that large cross-sectional area with the given slope to compute an unrealistic flow velocity

References

Andrews, E.D., 1980, Effective and bankfull discharges of streams in the Yampa River Basin, Colorado and Wyoming: Journal of Hydrology, v. 46, p. 311–330.

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Biedenharn, D.S., Copeland, R.R., Thorne, C.R., Soar, P.J., Hey, R.D., and Watson, C.C., 2000, Effective discharge calculation—A practical guide: United States Army Corps of Engineers ERDC/CHL TR-00-15, 63 p.

Gomez, B., 2006, The potential rate of bed-load transport: Proceedings of the National Academy of Sciences, v. 103, p. 17,170–17,173.

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National Cooperative Highway Research Program, 2004, Archived river meander bend database: Washington, D.C., Transportation Research Board of the National Academies, 4 CD-set.

Wolman, M.G., and Miller, J.P., 1960, Magnitude and frequency of forces in geomorphic processes: Journal of Geology, v. 68, p. 54–74.